Research Report 1238

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INTEGRATED PERSONNEL AND TRAINING
INFORMATION FOR TRADOC SYSTEM MANAGERS
(TSM): TECHNOLOGICAL GAPS

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Kinton, Incorporated

MANPOWER AND EDUCATIONAL SIMULATION TECHNICAL AREA

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The Integrated Personnel Support (IPS) model outlines the procedures that should be followed during the development of personnel and training subsystems for new materiel systems. This report identifies some of the technological problems that must be solved before benefits from the application of the IPS model can be achieved. These problems or "technological gaps" were identified during an extensive literature review for, and the subsequent development of, a handbook for TRADOC System Managers (TSM).
(Continued)

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Item 20 (Continued)

Most of the technological gaps related to deficiencies in procedures for estimating training and personnel requirements, and for the development of training strategies, during Phases I and II of the Army's Life Cycle System Management Model (LCSMM). Specifically, there was found to be an absence of satisfactory techniques for (a) deducing training and personnel re-quirements from materiel characteristics; (b) identifying excessive human resources demands stemming from materiel concepts; (c) identifying functions most appropriately performed by equipment, by persons, or by a man-machine combination; (d) generating task analytic data during Phase I of the LCSMM; (e) identifying high-risk training tasks during Phase I of the LCSMM; (f) indicating appropriate training strategies before actual hardware is developed; and (g) describing human resources data/requirements/constraints in terms that are meaningful to design engineers.

INTEGRATED PERSONNEL AND TRAINING INFORMATION FOR TRADOC SYSTEM MANAGERS (TSM): TECHNOLOGICAL GAPS

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FOREWORD
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    The Life Cycle System Management Model (LCSMM) outlines an orderly
series of steps that must be accomplished by all sponsor and contractor
organizations involved with the development of new Army materiel sys-
tems. TRADOC Regulation 600-4 outlines the Integrated Personnel Support
(IPS) process for integrating personnel and training considerations into
the development effort for new materiel systems. This report identifies
and describes the major missing information sources and procedures that
are needed for accomplishing the purposes of the IPS process. The data
for this report were obtained from an extensive review of civilian and
military publications and from structured interviews with TRADOC systems
managers (TSMs), their staffs, and related personnel.

    This research is part of ARI's 6.3 program and was accomplished
under Army Project 2Q763743A771. It is responsive to HRN 78-72 entitled:
"Simulation and Training Equipment Planning Sources (STEPS) Requirements
for Weapon System Development." This HRN was submitted by COL John W.
Swaren, Jr., Deputy Commander, Developing Systems Training and Devices
Directorate, U.S. Army Training Support Center (TRADOC), Fort Eustis,
Virginia. The advice and support of COL Swaren and his staff were in-
strumental to the successful completion of this research. The efforts
of Ms. Barbara Mroczkowski, who served as COL Swaren's point of contact,
were especially helpful in completing this project.

    This report will be of particular interest to all those who are
planning or conducting research and/or development efforts related to
the LCSMM or IPS process.

                                    JOSEPH ZEIDNER
                                    Technical Director

Integrated Personnel and Training Information
for TRADOC System Managers (TSM): Technological Gaps

BRIEF

Purpose:

The Life Cycle System Management Model (LCSMM) outlines an
orderly series of steps that must be accomplished by all sponsor and
contractor organizations involved with the development of new materiel
systems. The Integrated Personnel Support (IPS) model outlines the
procedures that should be followed during the development of personnel
and training subsystems to comply with the LCSMM. This report iden-
tifies some of the technological problems that must be solved to faci-
litate the application of the IPS model.

Procedure:

The technological problems or gaps reported on were identified
during an extensive literature review for, and subsequent development
of, a handbook for TRADOC System Managers (TSM), and through inter-
views with TSMs and their staffs. The handbook describes information
sources and technical procedures related to each of the IPS model
events discussed in TRADOC Regulation 600-4, Integrated Personnel
Support. Where possible technical sources of information that
described how to accomplish each IPS event are included. When satis-
factory documentation could not be found, a technological gap was said
to exist. In addition to technical reports, texts and handbooks, an
extensive search was made of military publications, especially ISD
manuals, Army regulations, training circulars and pamphlets, and
military specifications and standards. Also as part of this study
TRADOC System Managers (TSM) and their staffs, and other persons
tasked by TSMs, were interviewed for the purpose of identifying their
information requirements.

Findings:

Adequate techniques do not exist for identifying training and
personnel requirements during the early stages of the Life Cycle
Management Model. During the Conceptual Phase of the LCSMM in par-
ticular, there is a lack of techniques for generating data needed to
make estimates of training and personnel requirements. Moreover,
there is a lack of techniques for predicting the impact of materiel
design on training/personnel subsystems, making it difficult to
develop defensible training plans and cost-effectiveness estimates

during the Concept Phase of the LCSMM. More specifically, there is an absence of satisfactory techniques for:

- deducing training and personnel requirements from materiel characteristics, or the reverse

- identifying excessive human resources demands stemming from materiel concepts

- identifying functions most appropriately performed by equipment, persons, or by a man-machine combination

- generating task analytic data during Phase I of the LCSMM

- identifying high-risk training tasks during Phase I of the LCSMM.

- indicating appropriate training strategies before actual hardware is developed

- developing estimates of training costs and training effectiveness for alternative training strategies

- describing human resources data/requirements/constraints in terms that are meaningful to design engineers

It was concluded that solutions to the foregoing technological problems must be developed. If not, it seems unlikely that the gains expected through application of the LCSMM and IPS models will be achieved.

Utilization of Findings:

The results of this technical report will be used primarily as a planning document for further research designed to enhance the early development of the personnel and training subsystems of developing weapons systems. This document will be of interest to all those who are planning research and development efforts that are related to either the IPS or LCSMM models.

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STUDY OBJECTIVES

This report reviews selected technological gaps and problem areas
in existing procedures for the development of training and personnel
system development procedures. The report concentrates on deficien-
cies noted in the application of such procedures during the develop-
ment, earlier in this study, of a handbook on training management
guidelines for use with new materiel systems.

BACKGROUND

During recent years the development of improved procedures for
designing personnel and training systems has received considerable
attention. Numerous documents containing guidance material for the
design and implementation of training and personnel support systems
have been prepared. Recognizing the management and coordination
problems involved with such efforts, the Army has established TRADOC
System Manager (TSM) offices in the U. S. Army Training and Doctrine
Command. TSMs "are responsible for the integrated personnel support
(IPS) management of selected systems within TRADOC to ensure that per-
sonnel and training requirements are developed and fully integrated
early and continuously throughout the development cycle" (TRADOC
Regulation 600-4). To aid the TSM, handbooks have been developed that
describe in general terms the activities and products for which the
TSM is responsible (Hanson and Purifoy, 1978; MITRE Corp., 1977).

As part of the present study, a handbook for TSMs (Kinton, 1979)
was prepared to provide "a basic reference source of training manage-
ment guidelines and procedures for use in the life cycle development
of Army materiel systems." For each event described in TRADOC
Regulation 600-4, Integrated Personnel Support, this handbook outlines
the general procedures for accomplishing the event, the sources of
event input data, and the use of event products and output data.

During the development of this handbook, certain technological
gaps were identified. The major gaps so identified are: the lack
of needed data at various points in the formal system development
process; the lack of techniques for predicting the impact of materiel
design considerations on training/personnel subsystems, and the
reverse; and the difficulty of developing defensible training plans
and cost estimates during the early stages of materiel development.

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The development of solutions to these and other technical problems would greatly enhance the capability of training and personnel system developers.

The design of new materiel systems involves both the design of hardware and the design of an integrated support system, elements of which involve personnel and training (AR 700-127). The orderly and effective development of a new system must include the concurrent development of appropriate training and personnel subsystems. Training and personnel support subsystems may be more expensive than their materiel counterparts. Because of this cost factor and antici-pated shortfall of personnel for manning future weapons systems, it is imperative that future systems be designed to minimize the require-ments for personnel and the costs for training.

Increased interest in the early design of personnel and training subsystems has heightened our awareness that our ability to identify the relationship between equipment design and personnel and training requirements is both underdeveloped and underutilized. Currently training system development is based on the application of instruc-tional system development (ISD) procedures (TRADOC Pamphlet 350-30). These procedures describe how to generate and process data during a task and skill (front-end) analysis, a type of analysis that depends on the existence of hardware. This conventional task and skill analy-sis is difficult to perform on an equipment concept, and often is not conducted until a prototype of the new equipment becomes available. By the time such prototypes are available for analysis, it is usually too late for personnel and training considerations to have an impact on equipment design.

Also, within the realm of training, current development proce-dures do not enable us to make reliable comparisons between alter-native training options, especially when the comparisons involve a determination of training and personnel costs over the lifetime of a proposed system.

Historically, the development of new systems involved the design of hardware to meet a set of mission/functional requirements. Often it was tacitly assumed that the human components of the new system could compensate for deficiencies in system hardware or for functional requirements that could not be met by the hardware portion of the system. The approach was to design the materiel in keeping with known physical and physiological limitations of personnel and then to hope that through selection and training a cost-effective man-machine system could be produced.

This approach often resulted in the development of man-machine systems that function less than optimally in the field because
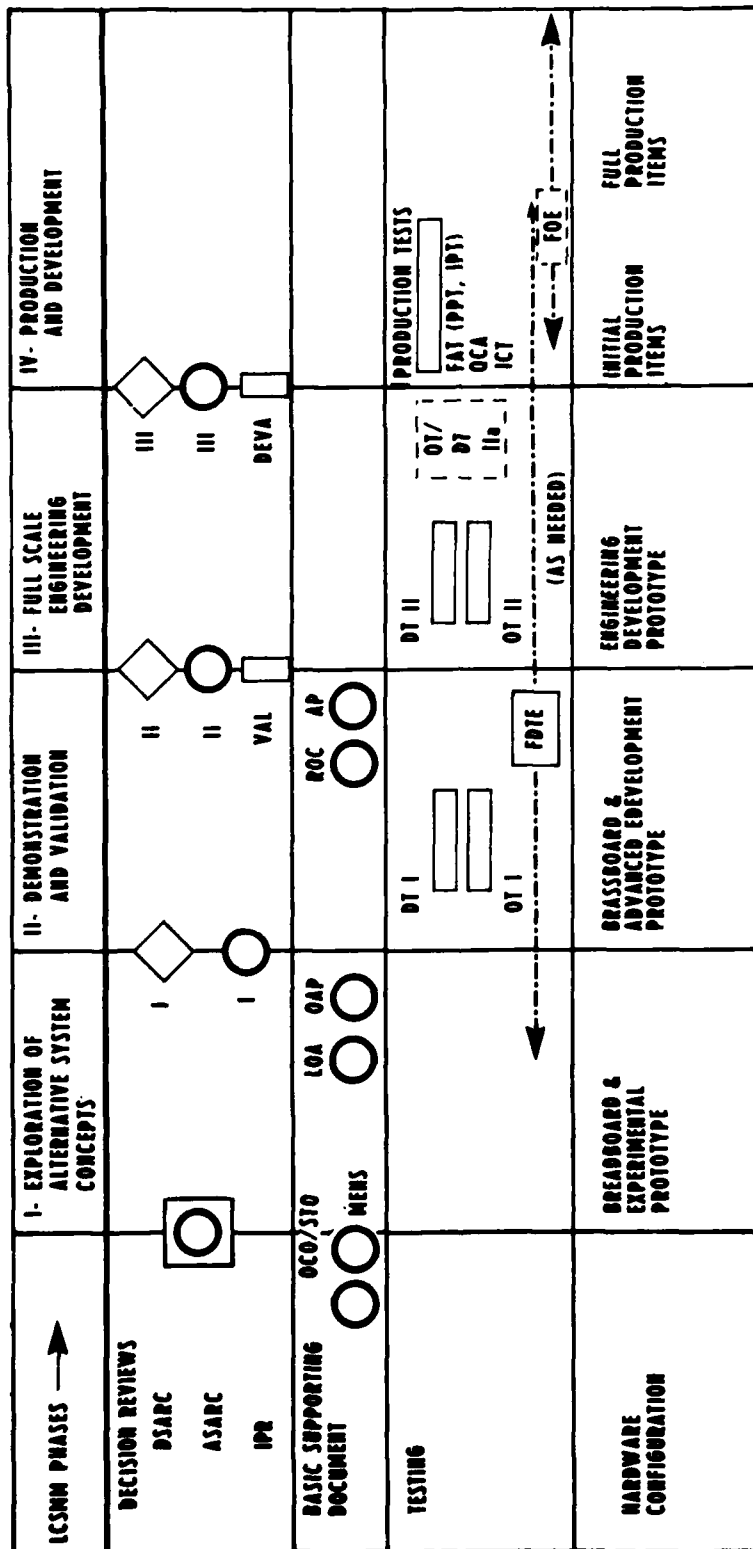
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excessive requirements are imposed on operator and/or or maintenance
personnel. Such problems tended to be compounded by the belief that
the development of a training subsystem could not begin until design
of the materiel had been completed. Consequently, it was not unusual
for new hardware to be fielded in the absence of suitable numbers and
types of persons to man the system.

In recognition of the foregoing problems, the Army developed the
Life Cycle System Management Model (LCSMM) for new systems. This model
outlines an orderly series of steps that must be accomplished by all
sponsor and contractor organizations involved with the development of
a new system (DA Pamphlet 11-25). The goal of the LCSMM is to pro-
mote the logical, coordinated, and carefully reasoned development of a
total system.

As shown in Figure 1 (17), the LCSMM subdivides the total life
cycle of materiel systems into four phases--the concept phase, the
validation phase, the full-scale engineering development phase, and
the production and deployment phase. Numerous regulations, pamphlets,
circulars, and handbooks have been prepared to describe the activities
that should occur during each of these four phases, including assigned
responsibilities and the recommended phasing for various activities.
The LCSMM stresses the coordinated development of all logistic support
systems in concert with new materiel. Milestones or checkpoints have
been established so that independent reviewers can certify that all
activities for any particular phase have been accomplished and docu-
mented satisfactorily before the system is allowed to progress to the
next phase of development.

During Phases I and II of the LCSMM, all portions of the new
system progress from a general concept stage through the development
and test of prototype materiel and procedures. During this process
many design options may be considered, both for materiel and for per-
sonnel and training subsystems. To aid in the selection of the most
appropriate option, numerous formal and informal trade-off studies may
be performed. Some of these studies may examine alternative personnel
and training approaches in an effort to identify those that are most
cost-effective.

Of particular interest to this report is the identification of
the points in Phases I and II of the LCSMM at which human resources
data and techniques can have an impact on materiel design. The ulti-
mate goal of the materiel development process is to design a total
system providing a cost-effective way to accomplish the mission needs
that initiated the development effort. The final system configuration
should be a cost-effective mix of materiel, personnel, training, and
other elements of the logistics support package.

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Figure 1. Systems Acquisition Cycle

LCSMM PHASES →	I - EXPLORATION OF ALTERNATIVE SYSTEM CONCEPTS	II - DEMONSTRATION AND VALIDATION	III - FULL SCALE ENGINEERING DEVELOPMENT	IV - PRODUCTION AND DEVELOPMENT
DECISION REVIEWS DSARC ASARC IPR	I I	II II VAL	III III DEVA	
BASIC SUPPORTING DOCUMENT	OCO/STO MENS LOA OAP	ROC AP		
TESTING		DT I OT I FDTE	DT II OT II (AS NEEDED)	PRODUCTION TESTS FAT (PPT, IPT) OCA ICT OT/ DT IIa FOE
HARDWARE CONFIGURATION	BREADBOARD & EXPERIMENTAL PROTOTYPE	BRASSBOARD & ADVANCED EDEVELOPMENT PROTOTYPE	ENGINEERING DEVELOPMENT PROTOTYPE	INITIAL PRODUCTION ITEMS / FULL PRODUCTION ITEMS

ASARC - ARMY SYSTEM ACQUISITION REVIEW COUNCIL
DEVA - DEVELOPMENT ACCEPTANCE
DSARC - DEFENSE SYSTEM ACQUISITION REVIEW COUNCIL
AP - ACQUISITION PLAN
DT I (II) - DEVELOPMENT TEST I (II)
FDTE - FORCE DEVELOPMENT TESTING AND EXPERIMENTATION
FOE - FOLLOW-ON EVALUATION
IPR - IN-PROCESS REVIEW
LCSMM - LIFE CYCLE SYSTEM MANAGEMENT MODEL

LOA - LETTER OF AGREEMENT
MENS - MISSION ELEMENT NEEDS STATEMENT
OCO - OCCUPATIONAL CAPABILITY OBJECTIVE
OAP - OUTLINE ACQUISITION PLAN
OT I (II) - OPERATIONAL TEST I (II)
ROC - REQUIRED OPERATIONAL CAPABILITY
STO - SCIENCE AND TECHNOLOGY OBJECTIVES
VAL - VALIDATION

Figure 1. Systems Acquisition Cycle

METHODOLOGY

This report discusses the needs for improved procedures for developing and making use of human resources data during the design of new materiel systems. These needs, or technological gaps, were identified during the extensive literature review for, and subsequent development of, the handbook for TRADOC system managers (Kinton, 1979) and through interviews with TSMs and their staffs.

For this report a "technological gap" is defined as the absence of documented procedural guidance describing how to accomplish a major event during the development of training or personnel subsystems. This definition allows the inclusion of a wide range of problem areas.

A study of any set of procedures--media selection procedures, for example--will show that they vary considerably in terms of specificity. At one extreme there are general media selection strategies that yield general procedural guidelines which can be implemented by experienced personnel. At the other extreme there should be specific "fully proceduralized media selection job performance aids," which provide detailed, step-by-step instructions and are designed for use by inexperienced personnel. In actuality, such aids do not exist. Military specification MIL-T-29053 (1977) is probably the closest approximation to such a fully proceduralized aid.

Experience gained during this research indicated that guidance material related to training and personnel subsystem development usually falls between the above two extremes. Many textbooks, technical reports, taxonomies, etc. provide the informational content one needs to develop one's own set of detailed procedures. Documents prepared by the military--ISD manuals (Berkowitz and O'Neal, In press), training circulars and pamphlets--military specifications and standards--attempt to provide more detailed procedural guidance. Even in these documents, however, procedures for making key decisions may be omitted, implying that they should be made on the basis of experience plus an understanding of the objectives that must be accomplished.

As an illustration, TRADOC Pamphlet 351-4 contains a detailed discussion of the procedures for selecting tasks for training. However, these procedures are based on the use of either four or eight factors that have to be weighted. They either receive equal weight (by default) or are assigned weights based on a command decision, which in turn usually is based on the professional judgment of experienced combat and training developers.

Technological gaps as defined and discussed in this report will not be eliminated by the preparation of descriptions of strategy and general procedures. They would be eliminated by the preparation of

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fully proceduralized performance aids. However, this latter approach would be an extremely lengthy and expensive undertaking.

A more suitable approach to eliminating these technological gaps might be to analyze training development events into their respective tasks, prepare procedural guidance covering these tasks, and prepare training material to cover the accomplishment of elements of those tasks. Essentially, this is the task analytic approach that the Army now follows when developing Skill Performance Aids (SPA).

TECHNOLOGICAL GAPS--MATERIEL DESIGN

DEDUCING TRAINING AND PERSONNEL REQUIREMENTS FROM MATERIEL CHARACTERISTICS

The successful development of major materiel systems is the culmination of a complex series of compromises and trade-offs. The desire for certain equipment capabilities sometimes must be discarded because these capabilities are not feasible within the present state of the art. The desire to meet certain materiel or operational requirements must sometimes give way when it is confronted with the realization that the people needed to man the proposed system cannot be provided. In recognition of these realities, the LCSMM was designed so that materiel-personnel trade-offs can be evaluated at least twice (OT I and II) before the materiel enters into production.

Until recently it was almost inevitable that when materiel and personnel considerations clashed, materiel requirements prevailed. In part this situation stemmed from the common assumption that the development of training programs must await the design of, and be subservient to, materiel developments. Practically all the concepts and procedural guidelines that have been formulated on how to design training subsystems are based on the assumption that training requirements will be deduced from materiel characteristics. Thus, during the development of training and personnel supply subsystems for new materiel, almost all activities are directed toward (a) defining and refining qualitative and quantitative personnel requirements; and (b) designing and refining individual and collective training plans.

During Phase I, the Concept Phase, of the LCSMM, materiel requirements are specified and tentative personnel and training requirements are identified. A major technological gap that exists relative to these activities concerns our lack of knowledge about the relationship between equipment characteristics and personnel requirements. As suggested by Meister (1973),

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There is a need for improved guidance for deducing
personnel numbers and type requirements from materiel
characteristics. In particular there is a need for
data relating equipment dimensions to skill dimensions.

During the initial design of materiel, numerous configurations
may be considered. Alternatives usually are discarded for other than
human resources reasons until one or a few options remain. Within
each of these options alternative subsystem designs options may have
been identified. For each of these subsystem alternatives, two
related questions need to be answered: (a) Given a set of materiel
alternatives, do the alternatives have different personnel or training
implications, and (b) given any specific alternative, how many persons
by MOS and skill level are required to support the system? Data
relating equipment dimensions to skill dimensions would be of con-
siderable aid when developing answers to such questions.

Comparability Analysis

A common way of estimating personnel and training requirements
for new materiel involves the use of comparability analysis procedures
(Goclowski, King, Ronco and Askrew, 1978). The concept of com-
parability analysis is widely known and practiced. It involves com-
paring features of proposed materiel with features of similar extant
equipment. If comparable subsystems and components are identified,
personnel and training data related to those subsystems/components are
used to estimate human resources requirements. When comparable sub-
systems and components cannot be identified, estimates of human
resources requirements are based on expert opinion. In practice, per-
sonnel and training estimates for new materiel made during the concept
phase for that equipment usually are based on a mix of historical data
and expert opinion.

The U.S. Air Force has been actively investigating and refining
comparability analysis techniques, yet considerable improvements to
the techniques are still needed. In particular, Goclowski et al.
(1978s, 1978b) report that the techniques do not seem to be exten-
sively employed during the Concept Phase, although this is probably
the most profitable locus of application. Therefore, as a tech-
nological gap:

There is a need for improved guidance for
identifying comparable systems and for.
historical data to help identify personnel
and training requirements, especially during
Phase I of the LCSMM.

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Identification of Excessive Human Resources Demands

The field of human engineering came about partly because of the need to know how to design materiel that could be operated by persons of specified physical and mental attributes. It is now possible to describe quite accurately how operator stations should be designed, what environmental conditions should not be exceeded, and so on. However, it still is difficult to identify, on the basis of materiel and/or operational concepts, when personnel requirements are excessive. We still design equipment that overloads the operator with data, and we still propose operational concepts that probably will result in excessive physical and mental fatigue before a typical mission is completed. Both Meister (1973) and Goclowski et al. (1978) discuss some of the problems in this area and as a technological gap conclude that:

> There is a need for techniques for reviewing
> materiel and the proposed operational use of
> materiel in order to identify where excessive
> demands may be placed on human resources.

Allocations of Functions to Equipment and Personnel

In a text by Meister (1973), excessive personnel demands are discussed in the context of function allocation. During the initial design of a new system, assumptions are made about which functions will be performed by equipment and which by individuals or crews. Engineering handbooks provide general guidance for identifying those types of functions best performed by humans. Meister believes that this guidance needs considerable improvement and as a technological gap reports that:

> There is a need for additional research on the
> conditions under which a function or task should
> be assigned to operator personnel as opposed to
> the materiel.

DEDUCING MATERIEL CHARACTERISTICS FROM HUMAN RESOURCES CONSTRAINTS

The discussion so far has been focused on the typical materiel development process--materiel requirements are identified and then personnel and training requirements are deduced. In the past few years it has become obvious that this approach must be modified. Currently and in the future, people requirements may be more difficult to meet than materiel requirements. The traditional design relationship between materiel and personnel requirements may have to be

reversed, placing both the materiel and the training/personnel developers into an unexplored area. In the immediate future the general requirement posed to the materiel developer may be: Given that the materiel will be manned by persons of a specific MOS and skill level, and that personnel quantities and training requirements will not exceed specified limits, design the materiel to meet these constraints.

As noted earlier, better guidance is needed for deducing personnel requirements from materiel characteristics. A more general statement of this requirement, or technological gap, is:

> There is a need for more information on the relationship between equipment design and numbers and types of personnel required. This information should provide the basis for deducing materiel requirements from personnel and training requirements/constraints, and vice versa.

Currently, engineers do not know how to design equipment to meet specific skill constraints nor do they know how to design equipment to achieve a reduction in skill level requirements. Moreover, equipment designers cannot answer such questions as: Given a specific number of persons as equipment operators, how should the equipment be configured to provide the most efficient performance?

At one time it was believed that technological advances, especially in automation, would result in materiel that could be operated effectively by less skilled personnel. So far the opposite has proven to be the case. A better understanding of the relationship between equipment dimensions and personnel requirements might have forewarned us of this outcome. Still, it seems helpful to explore ways to make better use of less skilled personnel. Is it possible to trade personnel numbers for skill level so that more persons of a lower skill can operate equipment as well as fewer persons of a higher skill? This and similar questions are worthy of continued study.

INCREASING THE IMPACT OF HUMAN RESOURCES CONSIDERATIONS
ON MATERIEL DESIGN

At numerous points during Phases I and II of the LCSMM, materiel design may be affected by human resources considerations and constraints. During Phase I, training and personnel requirements are identified and described in a Letter of Agreement (LOA). While these requirements are being developed, information may be generated to suggest that human resources constraints are being exceeded. During

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the allocation of functions to equipment and to personnel (Event A6 of the IPS model, TRADOC Regulation 600-4), a further indication can be derived as to whether proposed operators can or cannot perform the functions assigned to them. From a Cost and Effectiveness Analysis (CEA) of proposed training plans, estimates can be made of the extent to which cost or training time constraints may be exceeded. Finally, during preparation of the Advanced Development Contract, the materiel and training/personnel developers again have an opportunity to judge whether human resources requirements are excessive.

The manner in which human resources data are used by design engineers has received considerable study. Meister (1973) and Kidd and VanCott (1972) note that many crucial design decisions are made during preparation of the AD contract proposal and are never controverted. A proposal preparation team for a large system will include human factors engineers, especially if the contract states that HFE will be considered when developing the design for the proposed system. However, the mere presence of HF personnel is not enough. These persons must be willing to offer specific suggestions in response to specific questions about personnel and training (1972). Also, they must be willing to perform a rough task and skill analysis (TASA) quickly and on the basis of materiel concepts. This analysis should concentrate on (a) identifying excessive operator requirements; (b) calculating results/impact of excessive requirements; and (c) identifying equipment characteristics that might minimize personnel and training problems (10). The techniques for accomplishing the TASA in the absence of equipment have not been developed. Thus:

> There is a need for procedures describing how
> to quickly perform task and skill analysis as
> part of the process of refining design concepts,
> and then translating the data into estimates of
> training and personnel requirements.

Askren (1973) and Chapanis (1976) have noted that the way personnel and training requirements/constraints are typically worded has little meaning for a design engineer. The statement that the equipment must be designed to be operated by persons holding MOS XXX at the 3 skill level has no meaning to an engineer. His only recourse is to inquire whether similar extant equipment can be operated by such personnel. If so, that is the end of his consideration of personnel requirements.

As another illustration, the requirement that the total training program for the new system not exceed a cost of $5 million per year, adjusted for inflation, has no design implication for equipment designers. These illustrations indicate that:

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There is a need for guidelines on how personnel
and training recommendations/constraints should
be worded so that design engineers can understand
them and use them.

There is a need for ways to display human re-
sources data so that their impact on materiel design
or on training and personnel requirements becomes
more obvious.

The need for improved ways to display human resources data will be
discussed later in this report.

TECHNOLOGICAL GAPS--TRAINING PROGRAM DESIGN

The state of the art for training technology has shown substantial
advances in the past two decades. Instructional system design proce-
dures were developed, and refinements continue to be made. Task and
skill analysis techniques have been considerably refined, especially
as applied to the preparation of SPA materiel. Practically all these
advances, however, are based on the generation of data from existing
systems. As already noted in this report, techniques for applying
training technology during the Concept Phase of new materiel develop-
ment have not been well developed. Some of the technological gaps in
this area will now be reviewed.

TASK AND SKILL ANALYSIS FOR DEVELOPING SYSTEMS

TRADOC Regulation 351-4 emphasizes the importance of select-
ing tasks for training during the early stage of the training develop-
ment process. This regulation also stresses the importance of
developing a complete inventory of tasks prior to task selection.

Some of the problems associated with developing a task inventory
for new materiel already have been discussed. The techniques for
developing the inventory depend in part on comparability analysis
techniques, and these techniques need further refinement. Also, the
inventory depends in considerable measure on how functions are allo-
cated between operator positions and the equipment. Function alloca-
tion is another area in which adequate techniques do not exist.

Chapanis (1976) has discussed the difficulty of anticipating the
need for training to handle emergencies. He notes that with highly
automatic systems, operators monitor system operation until something
happens. Then they must respond rapidly and accurately. For systems
in the development stage, it is difficult to anticipate emergency

situations; it is easy to overlook tasks that must be performed to
correct operational emergencies or hazardous situations. The dif-
ficulty of identifying situations in which excessive operator require-
ments may result from materiel design or operational concepts has
already been noted.

Improved procedures for anticipating these situations should be
developed. In all probability, emergency situations would be identi-
fied as mission-critical or high-risk tasks for which appropriate
training material should be developed. In extreme instances, person-
nel studies during the Concept Phase might demonstrate that the pro-
posed design of the hardware must be modified because personnel
training and/or selection procedures cannot be expected to provide
persons able to cope with one or more of the emergency situations.

The training development procedures that can be utilized in the
above problem areas are, for the most part, applicable primarily to
individual tasks. Analysis techniques for developing an inventory of
collective tasks (tasks peformed by crews or units) are seldom
described in the literature. The most recent guidance for task and
skill analysis (TRADOC Pamphlet 351-4 and MIL-M-63035) does not
address the analysis of collective tasks. In view of these con-
siderations it appears that:

> There is a need for better techniques for apply-
> ing task and skill analysis procedures, especially
> those related to the development of task inventories,
> during the Concept Phase of the LCSMM. In addition,
> there is a need for improved guidance for developing
> an inventory of collective (crew) tasks during all
> stages of the LCSMM.

Selection of Tasks for Training

A training system does not attempt to provide training for all
individual and collective tasks. Many tasks are simple enough, or
common enough, that training is not required. There are tasks that
can be described well enough in technical manuals or in job perfor-
mance aids so that training is not required. Also, there are tasks
that must be taught by informal on-the-job training because funds are
not available to cover them during institutional training or in exten-
sion training material. Finally, there are some tasks that are not
trainable.

The selection of tasks for training is an extremely important
activity. For developing systems, training task selection is a designated
milestone. It is an activity performed jointly by the materiel and
training developers, and the result is an agreed-upon list of tasks
that will be covered by a training program or by SPA material.

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ISD manuals--TRADOC Pamphlet 350-30, and especially TRADOC
Pamphlet 351-4 devote considerable attention to the task selection
process. The most time-consuming and difficult task selection model
considers eight factors: percent of persons performing task, percent
of time spent performing task, consequences of inadequate performance,
task delay tolerance, frequency of performance, task learning dif-
ficulty, probability of deficient performance, and immediacy of per-
formance or time between job entry and task performance. A simpler
version of this model, bases task selection on only four factors: per-
cent of persons performing task, task delay tolerance, consequences of
inadequate performance, and task learning difficulty. These are the
four factors that many practitioners judge to be of greatest impor-
tance. Both of these models employ data that may be difficult to
generate for developing systems, especially during the Concept Phase
when the model must first be applied.

A third model, the DIF Model, selects tasks on the basis of
supervisor, job incumbent, and/or subject matter experts' judgments
about difficulty (D), importance (I), and frequency (F).

More research is required on the ease of use and the validity
of each of these models. In particular, further guidance is needed
on how the factors in each of these models should be weighted.
Currently weighting seems to be based on a command position that is
developed on the basis of professional judgment.

To further emphasize the importance of task selection during
Phase I of the LCSMM, it should be noted that data based on this acti-
vity are used to prepare an Outline Individual and Collective Training
Plan (OICTP), which in turn is used to prepare a Training Support
Plan. The result is a refined OICTP that provides the data for a Cost
Effective Analysis of the proposed training plans--the analysis
that provides the basis for judging whether the training plans are
acceptable. If they are accepted, the OICTP identifies those tasks
for which training material/programs will be prepared prior to OT I.
Thus, the selection of tasks for training during Phase I merits
increased emphasis. In view of these considerations it seems
appropriate to conclude that:

> There is a need for further investigation of the
> models that may be used to select tasks for training.

DEVELOPMENT OF TRAINING STRATEGIES

During the Concept Phase of the materiel development process,
estimates are made of the personnel, by MOS and skill level, required
to operate and maintain the new system. The tasks selected for
training are then allocated among these proposed operator and main-

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tenance positions, and a training plan outline is prepared for each
duty position. These training plans contain little detail. Rather,
they depict the training strategy by which personnel resources will be
developed. These strategies contain estimates of training settings,
training media, need for training devices, need for SPA material, and
so on.

Considerable guidance exists as to how to make such estimates
once detailed task and skill analysis data are available. However,
such guidance documents seldom discuss the application of these tech-
niques during the Concept Phase. For example, TRADOC Pamphlet 350-30
and TRADOC Pamphlet 351-4 both review procedures for selecting
instructional settings, but the readers of these documents are on
their own when applying these procedures to new materiel. Similarly,
numerous procedures exist for selecting media but these procedures do
not address media selection during the Concept Phase of materiel deve-
lopment. In fact, a recent report (Honeywell, 1978) suggests that
media selection techniques in general need considerable improvement.

Recent and on-going studies have been concerned with improving
guidance on designing training devices. When training devices are
first considered in the Concept Phase, the question is not how to
design them but rather whether they are needed at all. The problem is
one of deciding the strategy for using training aids and devices.
This involves making tentative selections among actual equipment
trainers, simulators, mock-ups, training aids, and so on. Further, it
involves estimating training device requirements in terms of the stage
of learning that the device is to support. The relationship between
stages of learning and training devices requirements has not been
fully explored. However, an article by Miller (1974) summarizes many of
the practical findings in this area.

According to Meister (1973) there is need for a task taxonomy that
would say: Given this task, equipment should be designed this way and
training should proceed as follows. The considerable research that
has gone into development of task taxonomy, plus their conspicuous
non-use, makes one wonder whether a useful taxonomy relating tasks to
training strategies can be developed.

A favorable indication comes from the observation that
experienced training developers can look at many operator and main-
tenance tasks and readily describe one or two strategies for teaching
that task. The major tasks performed by maintenance personnel already
have been classified into a small number of categories--inspect,
troubleshoot, adjust, remove/replace, etc. The development of two or
three different strategies for teaching each of these groups of tasks
should assist the preparation of an OICTP during the Concept Phase.
Similar groupings could be developed for operator tasks followed by

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the development of training strategies for each. With respect to a technological gap that seems capable of being successfully treated:

> There is a need for procedures, based on a task taxonomy approach, that would allow one to identify acceptable alternative training strategies for common operator and maintenance tasks. These procedures should address the additional factors that should be used to select from among the alternatives.

TECHNOLOGICAL GAPS--COST AND TRAINING EFFECTIVENESS ANALYSIS

More research is needed to provide guidance on applying cost-effectiveness techniques to the process of selecting training subsystems. TRADOC Pamphlet 71-10, no longer in force, provides a good description of various types of Cost and Training Effectiveness Analyses (CTEA) and some guidance on the general methodological approaches required by each type. Two on-going ARI-sponsored studies[1,2] each will prepare a guidance document describing how to conduct a CTEA. Also, a new regulation covering CTEAs is being prepared by the Army's TRADOC System Analysis Agency (TRASANA).

At present there is a tendency, created by the lack of specific guidance, to satisfy the CTEA requirement by showing that the use of simulators is less costly than the use of actual equipment for training operator and/or maintenance personnel. Although this procedure is often necessary, it may not be adequate. Other alternatives to the simulators may not have been evaluated and thus a "least cost" training solution was not reached. This tendency toward the cost-effective evaluation of training devices rather than of the entire training subsystem is caused by:

(1) A lack of basic data needed to perform such evaluations.

(2) A lack of comprehensive methodologies to apply to the various types of CTEAs.

(3) A lack of guidance for determining which type of CTEA and which methodology to use at a particular point in the LCSMM.

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[1]Development of a Cost/Training Effectiveness Manual for Use in LCSMM, ARI, Fort Bliss.

[2]Effectiveness of Infantry Systems: TEA, CTEA, and Human Factors in System Development and Fielding.

Admittedly this is a sequentia: type of problem; methodologies are not developed because basic data are not available, and guidance is not necessary because the methodologies are not developed. The problem is certainly not being ignored. Several on-going research efforts at ARI are exploring various aspects, and TRASANA is preparing to provide technical assistance in the performance of CTEAs for systems in the future. These efforts will undoubtedly improve the CTEA process. What is necessary is a comprehensive plan for incorporating the improvements achieved into the LCSMM.

The greatest shortfall in this area is the lack of basic data in the early (conceptual) phase of system development. The training subsystem, and possibly several alternatives, must be postulated from a list of critical tasks provided by the materiel developers. There are methods for accomplishing this process, some described in the accompanying handbook (11), but no significant basic data. The entire process is essentially a judgment call. It should be possible to compile our previous knowledge of system development and associated training subsystem development in such a way as to make the process of postulating a new training subsystem more deductive. As an example a handbook could be prepared in the fashion of weapons effectiveness handbooks, providing the basic relationships needed to determine training strategies in a simple and refinable format.

Cost data for CTEAs are more readily available but often are located in the files of specific users rather than being disseminated for general use. A compendium of the latest cost information and computations techniques, providing the cost of additional weeks of training, identifying the cost elements and sources of latest information on each, displaying unit training costs, etc., would be of great value to the CTEA study proponent.

If the above basic data were available, the necessary methodologies would evolve. In fact, some have. Approaches, some automated, have been developed for such areas as cost-effective selection of training media. Their use, however, is predicated on the availability of basic data, such as which media approach provides higher student performance on each of the critical tasks. Such decisions, particularly in the Concept Phase, are at present subjective, thus degrading the results of the media selection methodology. Methodology development should continue, but its need for basic data--which do not exist--should be considered, and the necessary basic research performed to provide the data.

The guidance problem also requires some research. TRADOC Pamphlet 71-10 describes three types of CTEAs--Train-up Study, (TUS), Training Analysis Cost and Operational Effective Analysis (TAC), and Training Developments Study (TDS). Although this document is no

longer in force, the descriptions of CTEA types and the requirements
of each type remain pertinent. Each may be a screening CTEA (quick-
look) that determines whether further analysis is necessary. If it
is, the TUS and the TDS are performed as stand-alone efforts and the
TAC is provided as input for the COEA. The problem is in determining
where in the LCSMM each type of study should be performed, if needed,
and what methodology to use with the data available at the time.

TECHNOLOGICAL GAPS--CODIFICATION OF HUMAN RESOURCES DATA

Training and human factors personnel are quick to criticize engi-
neers for not employing human resources data during the design of
materiel. As already noted, however, there is a lack of data
describing how equipment should be designed to accommodate various
types of persons or to foster proficient performance on various types
of tasks. Moreover, as Meister has observed (1973), very few techniques
are available for describing human resources data in terms that are
meaningful to the design engineer.

Experience with system development and with trade-off studies
over the years has identified the need for human resources data to
show the relationship of personnel/design/training/costs, generalized
from system experience and research, in the same way that human engi-
neering data have been displayed. There is a need for handbooks con-
taining charts, graphs, tables, etc. which show the relationship
between hardware characteristics and training time, personnel charac-
teristics and training, numbers of personnel vs. costs, and so on.
Such handbooks of data packages could be used by training developers
as they develop data for cost trade-off studies.

Persons in the human resources community are inherently reluctant
to make general estimates of the relationships between factors unless
these relationships have been confirmed under controlled conditions.
However, time and time again these same persons are asked to make
estimates about the quantities and types of persons needed to perform
certain tasks, or about the most effective form(s) of training
programs for teaching various tasks or various types of students.

Anecdotal evidence suggests that experienced personnel can make
fairly accurate estimates of human resources requirements for various
types of proposed materiel, especially if the proposed materiel is an
advanced version of something that exists already. Studies for the
Air Force's Human Resources Laboratory (Whalen and Askren, 1974) have
shown that technicians can make accurate predictions about the parame-
ters of general types of human resources data during the conceptual
design phase. As an illustration, experienced personnel can quite

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accurately estimate the average time required to repair various equipment subsystems and the size and composition of flight line repair crews.

Without attempting to base the relationship of functions on actual data, the data form of the relationship for various functions which enter into materiel-personnel/training trade-off studies may be depicted as shown in Figures 2 and 3.

Figure 2 illustrates the probable relationship between training time and aptitude scores. Training time might be shown in hours, weeks, or months and aptitude scores expressed in terms of clerical, electronic or mechanical aptitude with different charts prepared for different aptitudes. Such charts should be useful for determining the cost-effectiveness of certain approaches. For example, one could compare an approach that used large numbers of less capable persons with an approach that used fewer persons of a higher capability.

Figure 3 illustrates the probable relationship between maintenance man-hour requirements and the number of replaceable parts in the system. Parameters X, Y and Z represent average materiel reliability specifications. From such a chart, one could determine that the number of maintenance personnel required for a system is related to the number of parts that can fail (replaceable parts) and the reliability criterion for each part.

Many operator and maintenance tasks are quite similar across materiel systems. For each of these tasks two or more equally acceptable training strategies usually can be developed. However, these strategies may differ widely in terms of support requirements. It would seem possible, for such common tasks, to outline a set of training strategies for each and describe the implication of each strategy in terms of factors such as materiel training device, and instructor requirements. This information then could be used during trade-off studies and during Cost and Training Effectiveness Analysis studies.

In view of the foregoing considerations the authors believe that:

> Charts, graphs, tables, and other forms of handbook material should be prepared to summarize professional judgments about the relationships among: (a) equipment characteristics and personnel/training requirements; (b) task requirements and materiel and/or operational requirements; (c) task requirements and work demand conditions; and (d) task requirements and probable time and/or cost to train.

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Weeks of
Training Time

Entry Aptitude Scores

Figure 2. Training Time vs. Aptitude Scores

Number of
Replaceable
Parts in
System

(Log Scale)

Man Hours Per Year Required
to Perform Maintenance on One System
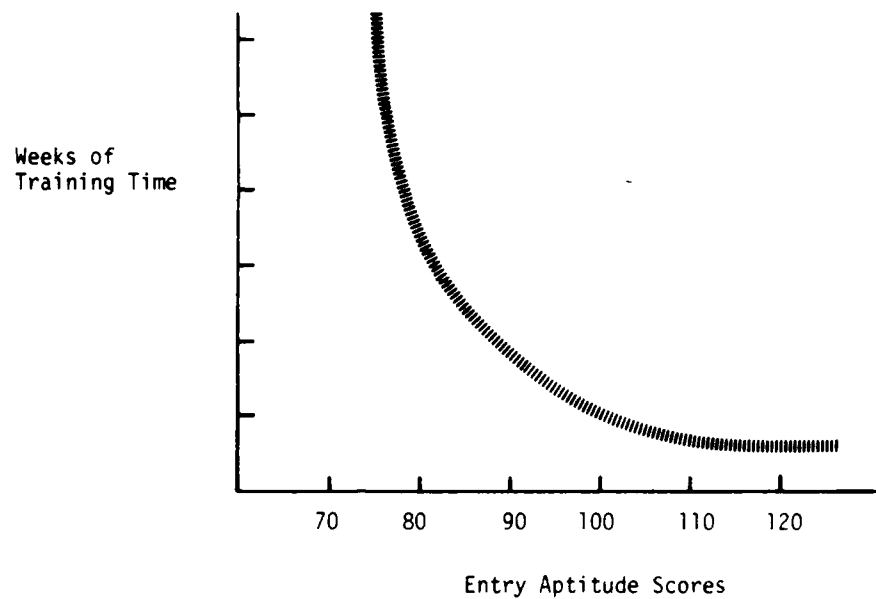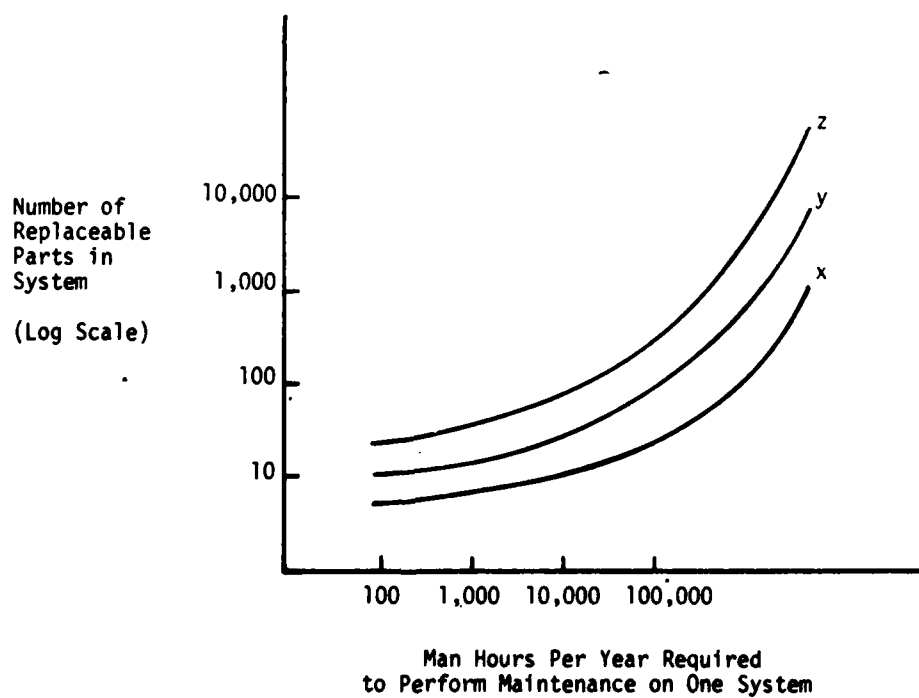
Where parameters x, y, and z represent average
(hardware) reliabilities of 90, 95 and 99%

Figure 3. Man Hours Required vs. Number of Parts

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SOME CONCERNS OF TRADOC SYSTEM MANAGERS (TSMs)

As part of this project TRADOC System Managers (TSMs) and their staffs, and other support personnel were interviewed for the purpose of identifying their information requirements. TSMs located at Forts Bliss and Sill were contacted, as were persons associated with the Training Development and Course Development Directorates at these two schools. Personnel attached to the Army Research Institute's Field Units at these posts also were queried. All were questioned regarding their activities relative to preparation of training programs for developing systems, the sources of information they use when engaged in such activities, their use of existing TSM handbooks, and their need for additional information concerning the developing of training subsystems for new materiel.

Based on these interviews, 26 problem areas were identified. These areas are listed in Table 1 and described in more detail in Appendix A. The interviewees also identified certain topics and content that might be included in future handbooks for TSMs. These are listed in Table 2 and described more fully in Appendix B. The interviewer's findings are summarized in the following paragraphs.

Currently most new systems are being developed on an accelerated schedule, and there is a concerted effort to reduce the entire developmental cycle to about five years. This is being attempted through the elimination of DT/OT III, and the complete or at least partial elimination of DT/OT I. Further, most of the studies, documents, training materials, and training equipment which should be developed prior to DT/OT II are being prepared by the prime contractor(s). As a consequence, it appears that many of the training and human factors considerations which should be addressed during Phases I and II of the LCSMM are receiving, or will receive, minimum attention. It seems probable, therefore, that many of the training system development problems which the Integrated Personnel Support procedures were designed to alleviate will instead be exacerbated by efforts to reduce and/or bypass major portions of the training system development process.

The interviewers were impressed with how much of the integrated personnel support system for new systems is contractor developed. This is now the rule, rather than the exception. Neither TSM offices nor School Directorates have the personnel needed to prepare the various documents and conduct the various studies called for in TRADOC Regulation 600-4. In the typical case, Individual and Collective Training Plans, Training Device Requirement studies, provisional QQPRIs, training materials, and training devices are developed under contract. Currently, the critical task of TSMs and other Army personnel is to monitor and evaluate contractor activities and products, and guidance for doing this needs considerable improvement.

Numerous TSMs expressed the need for "backward planning" guidance.
They desire a document that will help them plan backwards from a
scheduled ASARC/DSARC review or an Operational Test date. This guide
should describe the documents and materials which must be prepared
prior to those scheduled activities, approximately how long it will take
to prepare the documents/materials, and who is responsible for pre-
paring them.

At both Fort Bliss and Fort Sill, TSMs are located in adjoining
offices, yet there appeared to be little formal effort to exchange
experiences. In explanation of this seeming lack of cooperation,
the interviewers were told that each new system is different, is at a
different stage in the LCSMM, and is following a somewhat different
time line. Because of these considerations, many TSMs were of the
opinion that a detailed handbook for TSMs would have little overall
value. Some noted, however, that efforts to identify exemplary docu-
ments and disseminate these as models to all TSMs would be useful.
They also noted that the main commonality between all systems is the
requirement to hold scheduled ASARC/DSARC reviews at the end of each
phase of the LCSMM.

There was disagreement regarding the usefulness of handbooks
for TSMs. All TSMs were aware of the MITRE and ARI/TRADOC (Hanson
and Purifoy, 1978) TSM handbooks but reported little use of them.
Some interviewees discussed the need for more detailed "how to do it"
manuals for TSMs, manuals that would consolidate other references and
serve as a prime source document. Other interviewees were of the opi-
nion that detailed handbooks get out of date too quickly and do not
provide for enough flexibility of action; they favored the preparation
of guidebooks rather than "cookbooks".

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Table 1

PROBLEMS IDENTIFIED BY TRADOC SYSTEM MANAGERS
AND ASSOCIATED PERSONNEL

1. Compression of LCSMM into five years does not allow for enough
    time to concurrently develop a training system.

2. Human factors problems receive little consideration until an
    advanced prototype is available at OT II.

3. Most training-related documents, studies, and material for new
    systems are developed under contract. This increases the
    monitoring/evaluating burden of Army personnel.

4. Documents describing the LCSMM process are of only general use
    because each system is being developed under a different schedule.

5. Front-End Analysis (FEA) data often are acquired on an untimely
    and incomplete basis.

6. More guidance is needed regarding how to state training system
    requirements in RFPs and in contracts.

7. Better guidance is needed regarding how to evaluate statements of
    training device requirements (TDRs) as well as any training
    devices developed under contract.

8. Better guidance is needed regarding how to monitor and evaluate
    contractor efforts.

9. Improved guidance and methods are needed to support the
    conduct of CTEAs and COEAs.

10. Better guidance is needed regarding the staffing of the
    various documents which must be produced during the LCSMM.

11. TSM authority to task other TRADOC agencies is not clear.

12. More information about budgeting cycles and related lead times
    is needed by most TSMs.

13. Improved guidance is needed regarding how to prepare for ASARC/
    DSARC reviews.

Table 1 (Continued)

14. Better guidance is needed regarding how to "backward plan" from LCSMM milestones.

15. Improved guidance is needed regarding the format and contents of LCSMM-related documents.

16. No mechanism exists for identifying exemplary documents and informing TSMs about such documents. .

17. No formal procedures exist for sharing information among TSMs.

18. More guidance is needed regarding how to manage the development of systems under the Rationalization, Supportability, Interoperability (RSI) Program.

19. Some LCSMM-related documents that are not now action documents should be so designated.

20. Inaccuracies in Reliability, Availability, Maintainability (RAM) data can lead to conflicts regarding QQPRIs.

21. Better and less cumbersome media selection techniques are needed.

22. Validation of SPA material sometimes does not occur until after OT II.

23. Logistics agencies are sometimes slow to provide inputs to TSMs.

24. The definition of Initial Operational Capability (IOC) is unclear.

25. Persons assigned to a TSM's staff should be familiar with the general developmental cycle for new equipment.

26. No satisfactory procedures exist for preserving the "institutional experience" developed within a TSM office.

Table 2

SUGGESTED TOPICS/CONTENT FOR TSM HANDBOOK

1. Backward planning guidance

2. Proponent planning guidance

3. Information about the format and content requirements of key documents

4. Guidance regarding the preparation/review of RFPs and contracts

5. Guidance regarding how to monitor contractor efforts and to evaluate contract deliverables

6. Information describing TSM involvement with Operational Testing

7. Guidance regarding the role of other TRADOC agencies

8. Guidance regarding the conduct of CTEAs

9. Guidance regarding the Rationalization, Supportability, Interoperability (RSI) program

10. Guidance regarding how to assure consideration of human factors during early phases of the LCSMM

SUMMARY AND CONCLUSIONS

The Life Cycle System Management Model (LCSMM) outlines an orderly sequence of steps that must be accomplished during the development of new materiel systems for the Army. The Integrated Personnel System (IPS) model describes a related series of steps that should be followed to ensure that cost-effective and timely training and personnel subsystems are developed and tested concurrent with materiel development. It is anticipated that systems developed under these two models will be developed more rapidly, will be more cost effective, will have more effective support subsystems, and will require less retrofitting once they become operational.

The findings of this report suggest that the gains expected through application of the foregoing models will not be achieved because the techniques for executing various steps in the models exist only in rudimentary form, if at all. This conclusion is based on the existence of three categories of technological gaps which prevent adequate development of personnel and training subsystems until an advanced prototype of system hardware has been produced. These gaps concern:

(1) The lack of techniques for generating needed data at various points in the LCSMM development process.

(2) The lack of techniques for predicting the impact of materiel design on training/personnel subsystems, and conversely, the impact of these subsystems on materiel design.

(3) The difficulty of developing defensible training plans and cost-effectiveness estimates during the early stages of materiel development.

The existence of these and related technological gaps has been recognized for some time, and efforts are underway to fill these gaps with improved techniques. These efforts must continue, if the objective of fielding new materiel systems with well-trained personnel is to be achieved.

During Phase I of the LCSMM, alternative materiel concepts are investigated, and for each concept personnel and training requirements must be estimated. Development of these estimates is hindered by the absence of satisfactory techniques for:

(1) Deducing training and personnel requirements from materiel characteristics.

(2) Identifying excessive human resources demands stemming from materiel concepts.

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(3) Identifying functions most appropriately performed by
     equipment, by persons, and by some man-machine combinations.

During this Concept Phase of the LCSMM, the cost effectiveness of
alternative training plans must be assessed. This process depends on
the development of task and skill data, the identification of high-
risk training tasks, and the development of training strategies.
Existing Instruction System Development techniques and task analytic
techniques for accomplishing such activities assume that hardware
exists. However, during the Concept Phase for developing systems pro-
totype hardware does not exist. Thus, important personnel and training
decisions now must be based on guesswork or on data from comparable
systems or both. There is a need, therefore, to devise techniques
that can be applied during the Concept Phase of developing systems to
generate task analytic data, identifying high-risk training tasks, and
indicate appropriate training strategies before the actual hardware
system is in existence.

For future materiel systems it is quite possible that training
and personnel support subsystems will be more costly than their
materiel counterpart. Therefore, better techniques are needed for
developing estimates of training costs and training effectiveness for
alternative training strategies. Currently, baseline data upon which to
conduct cost studies of training and operational effectiveness are
usually lacking during the LCSMM Concept Phase. Also, there is an
absence of comprehensive and standardized methodologies for accomplish-
ing such st lies. On-going ARI-sponsored research may correct this
technological gap.

Human factors and training personnel often complain about the
lack of attention given to human resources considerations during
materiel design. Air Force studies have documented the legitimacy of
such complaints. However, many authors have noted the almost total
absence of techniques for deducing materiel characteristics from human
resources constraints. Techniques do not exist for describing human
resources data and/or requirements in terms that are meaningful to
design engineers. Until this technological gap is filled, it is un-
likely that materiel will be designed to meet anticipated constraints
in human resources.

In the past, new systems were designed to meet certain mission or
functional requirements, and it was assumed that, through selection
and training, the human components of the new system could compensate
for deficiencies in system hardware or for functional requirements
that could not be met by the hardware portion of the system. This
assumption is no longer tenable. The high cost of future training and
personnel systems, plus the anticipated shortfall of persons having
appropriate capabilities, makes it imperative that future systems be

designed to minimize training and personnel costs, while at the same time minimizing the need for exceptional personnel.

APPENDIX A

Problem Areas Identified by TRADOC System Managers (TSMs)
and Other Training Proponent Personnel

1. Compression of LCSMM into five years does not allow for enough
    time to concurrently develop a training system.

    Most new systems are being developed under an accelerated sche-
dule. OT III is being eliminated, and in some instances OT I is being
slighted or bypassed. When OT I is bypassed, competing contractors
develop prototype equipment which is first evaluated during a test
similar to OT II. The results of this evaluation, along with contrac-
tor-developed proposals for training systems, are used to select the
winning system. Limited production then will begin. The foregoing
developmental schedule probably will result in the deemphasis of
training and human factors considerations during the first two phases
of the LCSMM. It seems probable also that, because of competitive
reasons, contractors will be reluctant to allow Army personnel to
monitor their contractual efforts prior to the initial evaluation of
the competing systems.

2. Human factors problems receive little consideration until an advanced
    prototype is available at OT II.

    Potential human factors problems should receive initial con-
sideration during Phase I of the LCSMM, and should receive extensive
consideration during Phase II. In practice, human factors problems
receive little consideration until after OT II. For example, OT I or
its equivalent may be based on an evaluation of the feasibility of
available technology or on an evaluation of unintegrated portions of
the proposed system. It is difficult to identify potential human fac-
tors problems during such types of evaluation. Thus, human factors
problems may not be identified until OT II. By this time it is dif-
ficult to effect major changes in the hardware. This is likely to happen
for those systems being developed under the Rationalization, Support-
ability, Interoperability (RSI) program. Under this program all
equipment changes must be coordinated with and agreed to by allied
representatives. For some equipment provision has been made for
early inputs to Human Engineering Laboratory (HEL). However, these
inputs often are made after OT I.

3. Most training-related documents, studies, and material for new
    systems are developed under contract. This increases the
    monitoring/evaluating burden of Army personnel.

    The current trend is to contract out the development of as much
of the training system as possible. This means that Army employees
will be used increasingly to monitor and to evaluate the development
of training materials. Guidance regarding how to accomplish this
needs considerable improvment. Currently one can refer to various
Military Standards to determine whether SPA materials meet various
requirements. However, there are no standards for evaluating training
devices or such documents as Individual and Collective Training Plans
(ICTPs), provisional QQPRIs, and so on.

4. Documents describing the LCSMM process are of only general use
    because each system is being developed under a different schedule.

    The development schedule for a new system depends on how dif-
ferent it is from current systems, recent re-evaluation of the threat
which the system is designed to meet, recent technological advances,
and so on. Furthermore, many systems now under development were begun
before current LCSMM procedures were established. Thus, the time
schedule for each system is different (and determined primarily by the
Project Manager); certain key documents required by the LCSMM are pre-
pared on a retroactive basis; and certain key steps in the LCSMM are
bypassed on a "management by exception" basis. For these and other
reasons TSMs do not pay much attention to the details of the LCSMM.
What they attend to are scheduled ASARC/DSARC reviews. The schedule
for these reviews plus the scheduled time of IOC is what drives the
entire developmental cycle.

5. Front-End Analysis (FEA) data often are acquired on an untimely
    and incomplete basis.

    Front-End Analysis data supposedly are supplied initially
following award of the Advanced Development contract and are updated
after each Operational Test. These data are provided by the contractor.
Typically, they are not provided until after OT I and sometimes
not.until after OT II. The Army finds that FEA data provided for the
purpose of developing a Preliminary ICTP, QQPRI, Test Plan for OT I,
etc., usually are late in arriving and often are incomplete. This may
be a contractual problem which can be alleviated by more specific
contractual guidance and requirements. If this practice is to con-
tinue, the Army must be allowed to monitor the development of these
plans and documents in order to synchronize other subsystem
development.

6.   More guidance is needed regarding how to state training system
     requirements in RFPs and in contracts.

     TSMs and persons associated with school directorates often are
involved in the preparation of, or at least the review of, RFPs and
contracts. The preparation of these documents for new systems is of
critical importance because contractors are asked to produce many
of the products which heretofore were developed by Army employees. It
is especially important that the contract be written so that military
personnel will have the opportunity to closely monitor the development
of documents and material related to the training system. MIL-STD-
1388 (14) describes how SPA requirements should be written into an
RFP. Interviewees expressed a need for better guidance in other
areas.

7.   Better guidance is needed regarding how to evaluate statements of
     training device requirements (TDRs) as well as any training devices
     developed under contract.

     According to the LCSMM, training device requirements should be
identified in conjunction with the development of a preliminary
Individual and Collective Training Plan. The guidance implies
that TDRs should be developed by Army personnel. In practice the
requirement to identify TDRs often is incorporated into an RFP or a
Required Operational Capability (ROC) document. In such cases the
contractor has the responsibility for both identifying the need for
training devices and developing such devices. The responsibility of
Army personnel is to evaluate any statement of TDRs and any devices
developed by the contractor. Better guidance is needed on how to
accomplish this.

8.   Better guidance is needed regarding how to monitor and evaluate
     contractor efforts.

     As noted already, most of the documents and deliverables asso-
ciated with the LCSMM are produced under contract. The Army is
responsible for monitoring the development of these products and for
their evaluation. Numerous interviewees reported that there is little
guidance in these areas, and that the development of improved guidance
would be useful.

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9. Improved guidance and methods are needed to support the
    conduct of CTEAs and COEAs.

    The interviewees reported that little guidance exists regarding
how to conduct a Cost and Training Effectiveness Analysis (CTEA). In
addition to general guidance, the interviewees desired more
information on detailed methods for accomplishing CTEAs. This need
already has been recognized and is the subject of on-going, ARI-
sponsored research.

10. Better guidance is needed regarding the staffing of the
    various documents which must be produced during the LCSMM.

    TSM personnel did not agree as to the need for more detailed
guidance regarding the staffing of various documents and studies.
However, some TSMs and/or their staffs, reported that for certain
documents the staffing guidance was not clear.

11. TSM authority to task other TRADOC agencies is not clear.

    To accomplish their mission TSMs are authorized to interact
directly with other Army agencies. In most instances the nature of
this interaction is spelled out rather well in regulations. However,
TSMs also are authorized to use the services of other TRADOC agencies.
The nature of this authority apparently is not as clear as it might
be. Some TSMs expressed a desire to know more about their authority
to task other TRADOC agencies, what these other agencies could do for
them, the procedures for gaining their assistance, and the appropriate
entry points to these agencies.

12. More information about budgeting cycles and related lead times
    is needed by most TSMs.

    TSMs continually discover that they cannot obtain large amounts
of school support until the support requirements have been placed in
the school budget. This takes time. For example, if instructors are
required for OT II, it may take up to 29 months to obtain these
instructors through the normal budget cycle. If new facilities are
required for training, it usually takes five years to obtain these faci-
lities. TSMs and their staffs seldom are aware of the specific lead-
time requirements associated with their various requests. This type
of information would be of use to them. The Field Artillery School
has developed a budgeting slide rule which provides this information,
and has made it available to TSMs. Similar devices have been
developed for use at other Army schools.

13. Improved guidance is needed regarding how to prepare for ASARC/DSARC reviews.

There are four key dates in the LCSMM: the Initial Operational Capability (IOC) date, and the three ASARC/DSARC review dates. During each ASARC/DSARC review, a particular set of issues is addressed and a particular set of documents and other deliverables should be available. Numerous TSMs expressed an interest in having more definitive guidance regarding how to prepare for ASARC/DSARC reviews. In particular they wanted better guidance regarding the documents and deliverables that should be ready prior to these reviews. This is in keeping with the expressed needs of TSMs for more information that can be used for backward planning.

14. Better guidance is needed regarding how to "backward plan" from LCSMM milestones.

As previously mentioned, the critical dates in the LCSMM are those associated with the ASARC/DSARC reviews and with the IOC. Numerous TSMs expressed an interest in being provided with more backward planning guidance, especially with reference to ASARC/DSARC reviews. They would like to know what documents and other deliverables need to be ready at these points; they would like to have estimates of the time required to develop these deliverables; and they would like to know who should be tasked to develop the deliverables. The Directorate of Course Development at the Field Artillery School has developed a slide rule that can be used to determine lead time requirements for accomplishment of various training-related actions. More planning guidance of a similar nature would seem appropriate.

15. Improved guidance is needed regarding the format and contents of LCSMM-related documents.

In most cases each major document required as part of the LCSMM is described in a regulation. However, these regulations do not describe in detail the format of some of the required documents nor the topics that should be addressed. Numerous persons felt that more guidance, with examples, would be useful.

16. No mechanism exists for identifying exemplary documents and informing TSMs about such documents.

No formal means have been established for identifying good examples of LCSMM-related documents and disseminating this information to all TSMs. The TACFIRE ICTP has been labeled as a "GOOD" example of an ICTP and has been distributed to most TSMs. It was suggested that the TRADOC TSM Office might try to identify other exemplary documents and provide these to all TSMs.

17. No formal procedures exist for sharing information among TSMs.

As noted previously, there are no formal mechanisms for sharing information among TSMs. Most TSMs were of the opinion that some sort of information sharing should be useful, and suggested that the TRADOC TSM office might assume responsibility for such actions.

18. More guidance is needed regarding how to manage the development of systems under the Rationalization, Supportability, Interoperability (RSI) program.

Some of our new systems are being developed in cooperation with our allies. This means that prototype equipment and draft training material must be approved by a committee composed of all concerned parties, and changes cannot be made unless approved by all parties. Apparently, there is little guidance regarding what type of changes will have a major impact on the system and will require an agreement with our allies. For example, modifying equipment to correct a human factors deficiency may impact heavily on the assembly line of some German manufacturer. Some TSMs have had difficulty explaining to their staff the restrictions imposed by the RSI program.

19. Some LCSMM-related documents that are not now action documents should be so designated.

Some of the key documents developed during the first and second phases of the LCSMM are not action documents. In particular, the pre-liminary QQPRI is developed and then widely staffed as an information copy. A copy of the PQQPRI is forwarded to MILPERCEN but they are not not required to respond to this copy even if they are aware of potential conflicts between the proposed QQPRI and personnel recruitment plans. As a result, the TSM may develop a final QQPRI that is in conflict with MILPERCEN's perception of the types and quantities of people who can be provided in a future time frame. Such disagreements should be resolved as early as possible, otherwise systems that cannot be ade-quately manned may be developed.

20. Inaccuracies in Reliability, Availability, Maintainability (RAM) data can lead to conflicts regarding QQPRIs.

The development of a provisional QQPRI depends on the availability of RAM data. These data are obtained from the records of equipment similar to that proposed for the new system. When there are no similar equipments, RAM data are developed on the basis of professional judgment. During Phase I of the LCSMM, available RAM data are almost certain to contain inaccuracies, which can lead to conflicts between CDC, TSMs, and MILPERCEN regarding the composition of a QQPRI. For example, CDC might estimate that certain numbers of persons by MOS will be required to maintain the new system. Based on a Task and Skill Analysis performed either by the contractor or by a TRADOC school, the TSM may have different views regarding the numbers and types of persons required to man the system. To complicate matters further, MILPERCEN may claim that, based on its recruitment projections, it will not be possible to provide the persons required by either the CDC- or TSM-proposed QQPRI. Certain systems are now approaching their final stage of development without having an agreed-upon QQPRI.

21. Better and less cumbersome media selection techniques are needed.

During the development of Individual and Collective Training Plans, and the identification of training device requirements, numerous decisions must be made regarding the best media to employ. The interviewers were told that current media selection techniques are cumbersome and are of doubtful value. There seems to be no standard way by which TSMs or those tasked by TSMs attempt to handle this problem. Some seek assistance from NTDC. Others assign the problem to some group within the Directorate of Course Development. For still other systems, the contractor is responsible for matching training requirements and training media. It appears that the media selection problem arises in part because many people do not know how to employ existing media selection techniques and therefore tend to rely on historical precedent.

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22. Validation of SPA material sometimes does not occur until after OT II.

The need for SPA material should be identified during Phase I of the LCSMM, and critical portions of this material should be evaluated during OT I. All SPA material should be available for evaluation during OT II. Apparently this is seldom the case. In many instances SPA material is not available even by OT II. Also, SPA material, especially TEC material, often arrives in an unsatisfactory state and has to undergo extensive and expensive revisions before it can be demonstrated to be effective. It was noted also that there are no good procedures for assessing the readability level of figures, diagrams, and charts.

23. Logistics agencies are sometimes slow to provide inputs to TSMs.

TSMs must coordinate their activities with various agencies. Often this is done through the convening of meetings. Some TSMs reported that logistics agencies tend not to send representatives to such meetings. Therefore, inputs from logistics agencies tend to be untimely and may not even be provided.

24. The definition of Initial Operational Capability (IOC) is unclear.

Some confusion was expressed regarding the definition of IOC. Apparently IOC has been defined as (a) when the first operational piece of equipment becomes available, and also as (b) when the first unit to receive the new equipment becomes operational. TRADOC Regulation 600-4 clearly employs the second definition. If the first definition is used, the training system would have to be developed much more rapidly than if the second is used.

25. Persons assigned to a TSM's staff should be familiar with the general developmental cycle for new equipment.

Some TSMs and their staffs are not familiar with the development cycle for equipment. They noted that this basic knowledge should be required of TSMs. Without it, they will have difficulty understanding the LCSMM and coordinating their training system development activities with equipment development schedules.

26. No satisfactory procedures exist for preserving the "institutional experience" developed within a TSM office.

For most officers, serving as a TSM or a staff member of a TSM office is a one-tour assignment. Generally speaking, each TSM office contains four officers and one civilian clerk-typist, none of whom have had prior experience related to TSM activities, and few of whom have ever had experience related to the development of training systems. Experience developed during a tour in a TSM office is lost unless the TSM and his staff serve overlapping tours with their replacements. In some instances this does occur. The use of civilian aides to staff TSM offices was discussed, but this probably would not help much since civilians also change job positions quite often. The use of overlapping tours seems to be the best way to preserve "institutional" experience.

Another way might be to develop workshops for TSMs, an approach that has been tried with some success. As a third alternative, data and how-to-do-it information could be made available at the local level by means of a management information system. TRADOC plans to develop a CONUS-wide computer-supported management information system makes this a viable alternative. Such a program would allow for immediate update of both procedural and methodological information and encourage the exchange of lessons learned among TSMs.

APPENDIX B

SUGGESTED TOPICS/CONTENT FOR TSM HANDBOOK

1. Backward Planning Guidance

This information would identify the major milestones in the LCSMM and for each describe the documents, studies, and other deliverables which should be prepared by those milestones. If possible, this guidance should include information about lead times, and about who should be tasked to develop specific deliverables. The most important milestones would be the three sets of ASARC/DSARC reviews and the IOC.

2. Proponent Planning Guidance

This type of planning information is somewhat similar to that described above, but would concentrate on identifying for Training and Course Development Directorates the materials they should provide or procure and the dates by which they should be ready for use. Items which proponent schools have to produce/procure include facilities, instructors, students for various testing periods, instructors for OT II, and so on. It is important that proponent schools be made aware of such requirements early enough so that the requirements can be incorporated into their budgeting and scheduling cycles.

3. Information about the Format and Content Requirements of Key Documents

All key documents which must be produced as part of the LCSMM are described in a regulation. Most of the regulations describe format and content requirements in general terms. The interviewees expressed a need for more detailed information about such documents, especially about the topics, questions, and issues that should be addressed. In addition, it was noted that a handbook containing exemplary documents to serve as models would be useful.

4. Guidance Regarding the Preparation/Review of RFPs/Contracts

Typically, someone within a TSM office or within a school directorate will be asked to review or even to prepare certain portions of an RPF or contract. In some instances Mil Standards contain material that can be incorporated into an RFP/contract, and a few documents illustrate how certain requirements should be stated in an RFP. These and similar guidance material should be examined to determine whether additional material should be prepared to cover other contractual

requirements. For example, how should the requirement to develop a preliminary Individual and Collective Training plan or a provisional QQPRI be stated in a contract?

5. Guidance Regarding How to Monitor Contractor Efforts and to Evaluate Contract Deliverables

For certain contractor-developed deliverables, guidance regarding how to evaluate them does exist. For other documents and products, guidance does not exist in a readily usable form. Assuming that in the future contractors will be required to develop most LCSMM-related training documents and products, it seems appropriate to identify those deliverables for which monitoring/evaluating guidance does not now exist, and then to prepare such guidance.

6. Information Describing TSM Involvement with Operational Testing

Some TSMs have had difficulty clarifying their role during OT II. Operational Testing is conducted by OTEA, but TSMs are involved with preparations for OT II, and are responsible for assuring that certain training-related items are available. They also are responsible for assuring that appropriate instructors and/or operators are available at OT II. These and other TSM requirements with regard to OT II need to be clearly established.

7. Guidance Regarding the Role of Other TRADOC Agencies

TSMs are authorized to task other TRADOC agencies, but this tasking authority sometimes is not clearly stated in the TSM charter. In addition, many TSMs seem unclear about the services that can be provided to them by other TRADOC agencies, and the appropriate entry points into these agencies. These and related subjects could be described more specifically in a TSM handbook.

8. Guidance Regarding the Conduct of CTEAs

TSMs are responsible for assuring that CTEAs are conducted. At present it is not clear what the minimum requirements of a CTEA are and how to approach the problem. Furthermore, little guidance exists regarding how to conduct a CTEA. This problem is the subject of on-going studies. The best approach at present seems to be to rely on past efforts as examples.

9. Guidance Regarding the Rationalization, Supportability, Inter-
   operability (RSI) Program

   Certain of our new weapons systems are being developed in
cooperation with our allies. The goal is to develop weapons systems
which can be supported, operated, and even manufactured by our allies.
Under this program a TSM has to prepare a Memorandum of Understanding
with representatives of our allies. Any changes made to prototype
equipment and critical items of training material must be agreed to by
all involved allies. Those TSMs involved with the RSI program noted
the need for information about the program. They especially expressed
a need for information about what, if any, changes to prototype equip-
ment and training devices/material can be made without consultation
with our allies. Though these requirements are on a case by case
basis, guidance is needed on the design, economic, and political con-
siderations of such changes.

10. Guidance Regarding How to Assure Consideration of Human Factors
    during Early Phases of the LCSMM

   Efforts to condense the LCSMM cycle, and to develop most training-
related material under contract may have the effect of reducing human
factors considerations during the first two phases of the LCSMM. At
the very least it would seem that those preparing RFPs/contracts
should be made aware of the need to examine early equipment concepts
and prototypes in terms of potential human factors problems. The
RFP/contract should emphasize that the contractor is responsible for
assuring that major human factors problems do not exist in prototype
equipment. Furthermore, the RFP/Contract should provide for the exa-
mination of equipment concepts and prototypes by HEL or some other
suitable agency. Information on this subject could be incorporated
into a TSM handbook.

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